Real Time Multi-Sensor Data Acquisition and Processing for a Road Mapping System

by

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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ABSTRACT

Road assets condition has a critical impact on road safety and efficiency. Accurate and efficient monitoring and management of road assets is a challenge. This research is focused on developing a cost efficient mobile surveying system to tackle this challenge. The system is equipped with LADARs (LAser Detection And Ranging) and a camera as exteroceptive sensors, and other sensors including Inertial Measurement Units (IMU), odometer and GPS (Global Positioning System). This system can acquire road assets information expeditiously in highly dynamic environments, where data collection has previously been inefficient, laborious and even dangerous.

Continuous Position, Velocity and Attitude (PVA) information is obtained by the integration of IMU, GPS, camera and odometer. Then PVA information is fused with range and remission data from LADARs to achieve multiple functions for road assets surveying and management. The functions include road clearance surveying, road surface profiling, 3D structure modelling, road boundary detection and road roughness measurement. The processing results are presented in a user-friendly graphical interface and can be saved as videos for convenient data management.

Two sets of GUI (graphical user interface) have been developed for data acquisition from all the sensors and data processing for the system functions. A Data Acquisition GUI is used for sensors control, data acquisition and pre-processing. It has multiple functions, including configuring LADARs scan frequency and resolution, displaying and recording data and exporting data with the required format. The Data Processing GUI includes various algorithms to perform all the data processing and management functions.

The camera in the proposed system provides not only a vision reference, but also visual odometry for improving PVA estimation when GPS is unreliable. In order to obtain a robust and accurate visual odometry, a new algorithm named PURSAC (PURposive SAmple Consensus) has been purposed for model fitting, which purposely selects sample sets according to the sensitivity analysis of a model against sampling noise and other information. This in turn can improve the accuracy and

robustness of fundamental matrix estimation, resulting in a more precise and efficient visual odometry.

A prototype system designed for online data processing has been developed and four road tests have been successfully completed. Experimental results on a variety of roads have demonstrated the effectiveness of the proposed mobile surveying system.

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3D	Three Dimensional
APB	Advanced Protective Barrier
DPA	Data Processing Algorithm
GPS	Global Positioning System
GUI	Graphical User Interface
IMU	Inertial Measurement Unit
IRI	International Roughness Index
ISF	Integrated Sensors Frame
LADAR	LAser Detection And Ranging
LMS	Laser Measurement Systems
MLESAC	Maximum Likelihood Estimate for SAmpling Consensus
PROSAC	Progressive Sample Consensus
PURSAC	PURposive Sample Consensus
PVA	Position, Velocity and Attitude
RADAR	Radio Detection And Ranging
RANSAC	RANdom Sample Consensus
SURF	Speeded Up Robust Features
VO	Visual Odometry